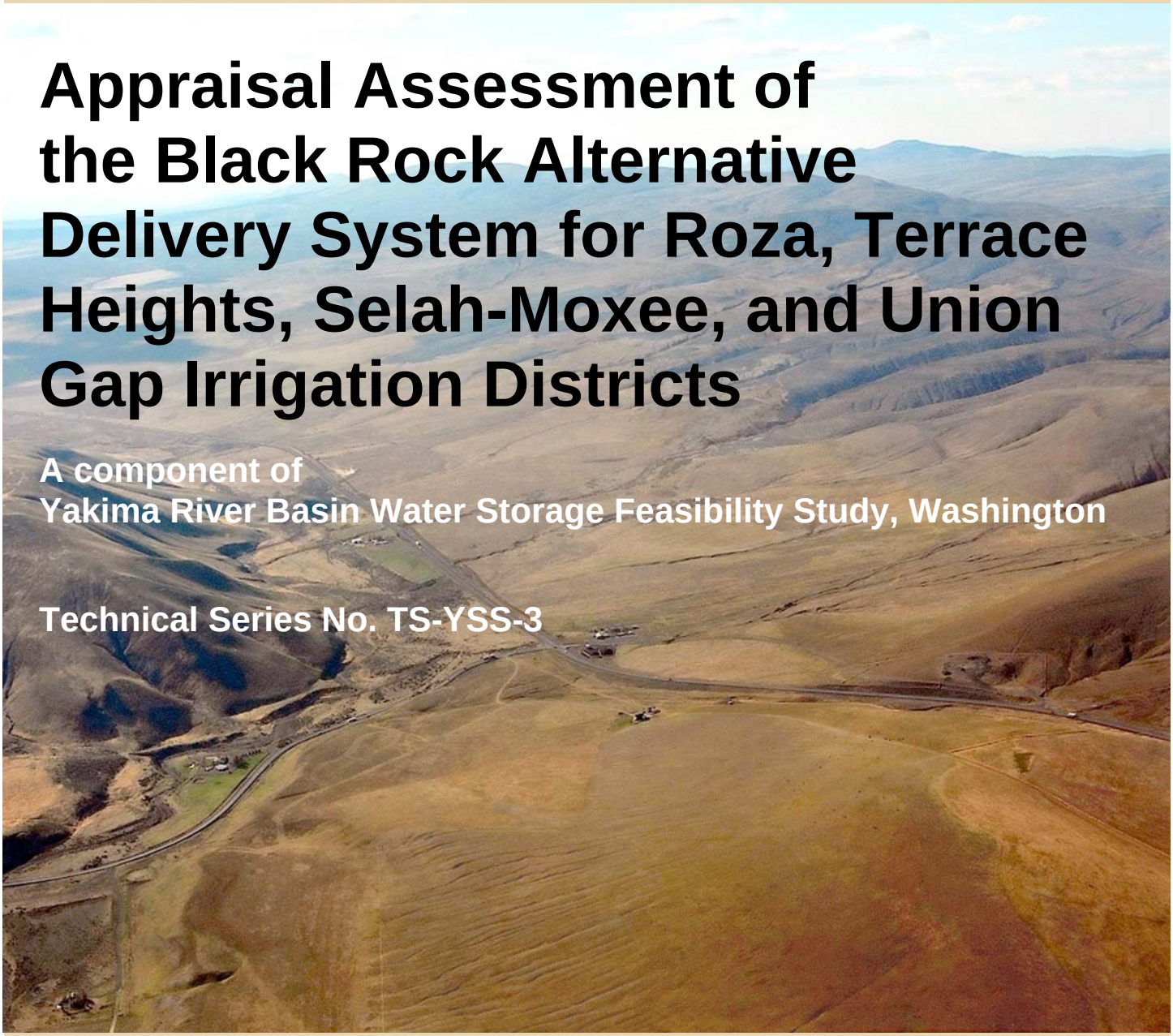
RECLAMATION

Managing Water in the West

Appraisal Assessment of the Black Rock Alternative Delivery System for Roza, Terrace Heights, Selah-Moxee, and Union Gap Irrigation Districts

A component of
Yakima River Basin Water Storage Feasibility Study, Washington

Technical Series No. TS-YSS-3



Black Rock Valley

U.S. Department of the Interior
Bureau of Reclamation
Pacific Northwest Region

December 2004

The mission of the Department of the Interior is to protect and provide access to our Nation's natural and cultural heritage and honor our trust responsibilities to Indian Tribes and our commitments to island communities.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

Yakima River Basin Water Storage Feasibility Study, Washington

APPRAISAL ASSESSMENT OF BLACK ROCK ALTERNATIVE DELIVERY SYSTEM FOR ROZA, TERRACE HEIGHTS, SELAH-MOXEE, AND UNION GAP IRRIGATION DISTRICTS

December 2004

Prepared by

U.S. Department of the Interior

Bureau of Reclamation

Pacific Northwest Region

Glossary and Acronyms

Black Rock outlet facility	a potential facility to divert water at the downstream end of the outflow conveyance system into potential or existing Roza and Sunnyside Divisions' delivery systems; this facility would include a bifurcation works and a Black Rock powerplant
Black Rock powerplant	a potential powerplant near Roza Canal MP 22.6 at the potential Black Rock outlet facility
cfs	flow rate in cubic feet per second
delivery systems	the potential canal, pipeline, or tunnel systems that would deliver water from the potential Black Rock outlet facility to the existing or modified Roza and Sunnyside Divisions' canal systems for delivery to Yakima Project lands
Facilities Report	the *Appraisal Assessment of the Black Rock Alternative Facilities and Field Cost Estimates Technical Services No. TS-YSS-4 December 2004;* prepared by Reclamation's Denver Technical Service Center
hydraulic grade line	the surface or profile of water flowing out of hydraulic gradient; the slope of the hydraulic grade line is under pressure; the hydraulic grade line is the actual level to which water would rise in a small vertical tube connected to the pipe
hydraulic gradient	the slope of the surface of open or underground water
kW, kWh	kilowatt, kilowatt-hour
MP	mile post – refers to locations on the Roza Canal with MP 0.0 being at Roza Diversion Dam
MW, MWh	megawatt, megawatt-hour
outflow conveyance	the potential system and facilities that would release water stored in a Black Rock reservoir and convey it to a downstream Black Rock outlet facility
PRV	pressure relief valve
Reclamation	Bureau of Reclamation of the U.S. Department of the Interior,
RM	river mile – refers to locations on either the Yakima River or the Columbia River
Roza Division	a division of the Yakima Project comprised of Roza Irrigation District
Roza Powerplant	the existing powerplant located at Roza Canal MP 11
Roza-Selah lands	those irrigated lands upstream from the inlet of Roza Canal Tunnel No. 3
SH	State Highway
storage facilities	a potential Black Rock dam and related facilities that would impound in a Black Rock reservoir the Columbia River water received via an inflow conveyance system
Storage Study	*Yakima River Basin Water Storage Feasibility Study*; a multi-year evaluation of the viability and acceptability of several storage augmentation alternatives, including potential water exchange and storage augmentation for the benefit of fish, irrigation, and municipal water supply within the Yakima River basin
Sunnyside Division	a division of the Yakima Project, comprised of Sunnyside Valley Irrigation District and eight other irrigation districts, companies, and cities
Sunnyside Canal powerplant	a potential new powerplant at Sunnyside Canal MP 3.83

PREFACE

The Congress directed the Secretary of the Interior, acting through the Bureau of Reclamation (Reclamation), to conduct a feasibility study of options for additional water storage for the Yakima River basin, Washington. Section 214 of the Act of February 20, 2003 (Public Law 108-7) contains this authorization and includes the provision "… with emphasis on the feasibility of storage of Columbia River water in the potential Black Rock Reservoir and the benefit of additional storage to endangered and threatened fish, irrigated agriculture, and municipal water supply."

Reclamation initiated the *Yakima River Basin Water Storage Feasibility Study* (Storage Study) in May 2003. As guided by the authorization, the purposes of the Storage Study are to identify and examine the viability and acceptability of alternate projects by: (1) diversion of Columbia River water to the potential Black Rock reservoir for further water transfer to irrigation entities in the lower Yakima River basin as an exchange supply, thereby reducing irrigation demand on Yakima River water and improving Yakima Project stored water supplies, and (2) creation of additional storage within the Yakima River basin. In considering the benefits to be achieved, study objectives will be to modify Yakima Project flow management operations to most closely mimic the historic flow regime of a Yakima River system for fisheries, provide a more reliable supply for existing proratable water users, and provide additional supplies for future municipal demands.

State support for the Storage Study was provided in the 2003 Legislative session. The capital budget included a $4 million appropriation for the Department of Ecology (Ecology) with the provision the funds "… are provided solely for expenditure under a contract between the Department of Ecology and the United States Bureau of Reclamation for the development of plans, engineering, and financing reports and other preconstruction activities associated with the development of water storage projects in the Yakima river basin, consistent with the Yakima river basin water enhancement project, P.L. 103-434. The initial water storage feasibility study shall be for the Black Rock reservoir project."

Reclamation's Upper Columbia Area Office in Yakima, Washington, is managing and directing the Storage Study. Pursuant to the legislative directives, Reclamation has placed initial emphasis on Black Rock alternative study activities. These study activities are collectively referred to as the Black Rock Alternative Assessment (Assessment).

The Assessment has three primary objectives. First, it provides the emphasis directed by Federal and State legislation. Second, it builds upon prior work and studies to provide more information on the configuration and field construction cost of the primary components of a Black Rock alternative; it examines legal and institutional considerations of water supply and use, and identifies areas where further study is needed. Third, it is a step forward in identifying the viability of a Black Rock alternative.

This technical document, prepared by Reclamation's Pacific Northwest Construction Office in Yakima, is one of a series of documents prepared under the Storage Study. This particular document is a component of the Assessment reporting on preliminary appraisal-level engineering evaluation of designs and cost estimates of a potential Black Rock delivery system for the Roza Division of the

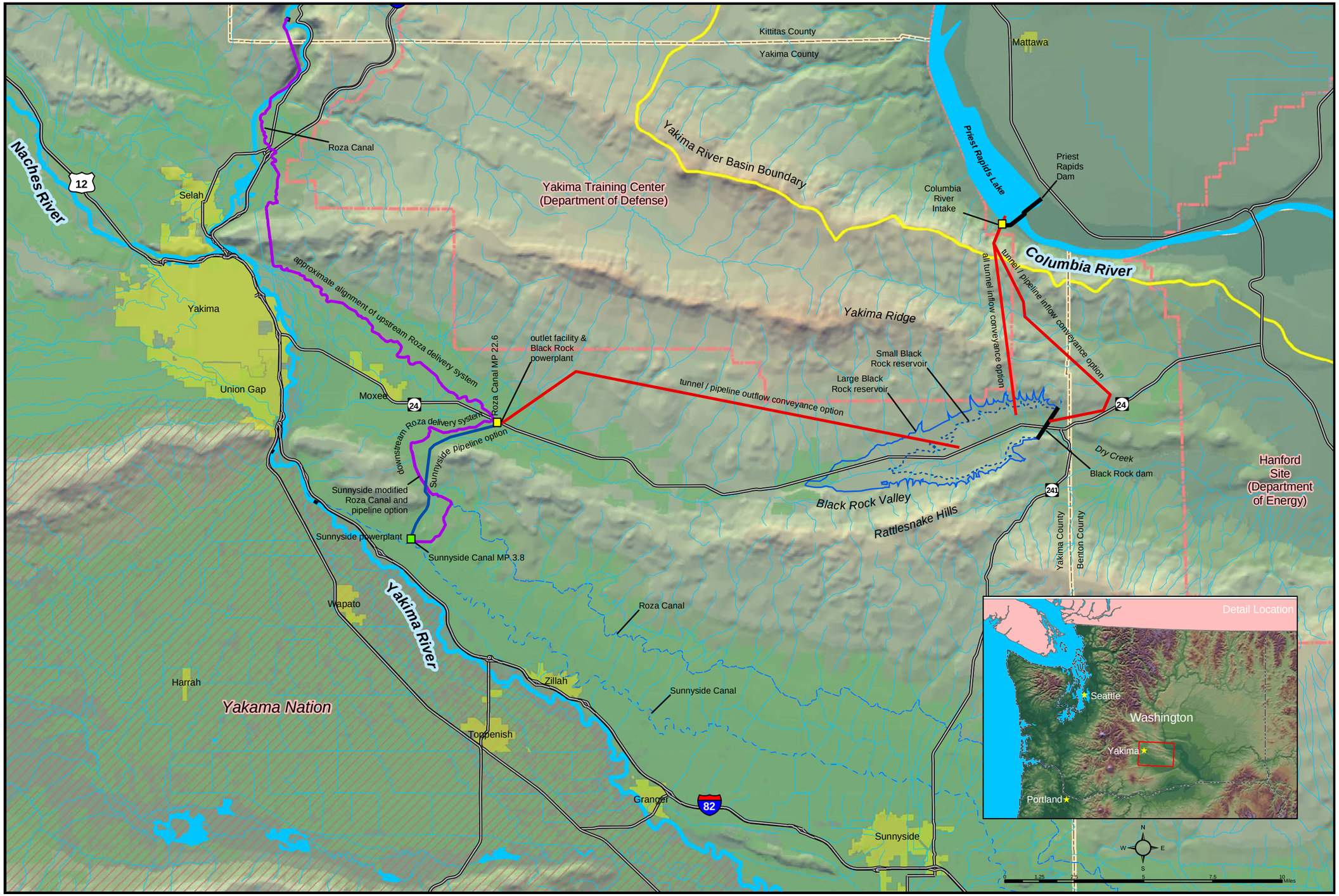
Yakima Project. Information and findings of this technical document are included in the Assessment Summary Report.

FURTHER CONSULTATIONS

The information available at this time is necessarily preliminary, has been developed only to an appraisal level of detail, and is therefore subject to change if this alternative is investigated further in the course of the Yakima River Basin Storage Feasibility Study (Storage Study). Finally, economic, financial, environmental, cultural, and social evaluations of the Black Rock alternative have not yet been conducted.

The policy of Reclamation requires non-Federal parties to share the costs of financing feasibility studies and the eventual construction of Federal reclamation projects. In light of this policy, the preliminary cost estimates presented in the Assessment Summary Report, and current Federal budgetary constraints, Reclamation is not reaching a decision at this time as to whether the Black Rock alternative will be carried forward into the next phase of the Storage Study or dropped from further consideration. Rather, Reclamation will consult with the State of Washington (which is cost sharing in the Storage Study), the Yakama Nation, the potential water exchange participants, project proponents, and other interested parties before making a decision in this regard. It is anticipated that a decision will be reached by the fall of 2005.

If the Congress provides further funding for the Storage Study, all technically viable alternatives would be compared and an alternative(s) selected for further analyses in the feasibility phase. (Whether the Columbia River-Yakima River water exchange concept in the form of the Black Rock alternative is included will depend upon whether Reclamation, after these additional consultations, decides to carry that alternative forward into the plan formulation phase of the Storage Study.) The selected alternative(s) would then be subject to detailed evaluation in the feasibility phase in terms of engineering, economic, and environmental considerations, and cultural and social acceptability. This feasibility phase would be the last phase of the Storage Study. Preparation of the Feasibility Report/Environmental Impact Statement would be a part of this final phase.



Preface Figure 1. Location Map and Black Rock Alternative Facilities Options

CONTENTS

FIGURES

TABLES

ATTACHMENTS

1. INTRODUCTION

A primary consideration as to the viability of a Columbia River water importation alternative is whether existing irrigation water users are so situated and willing to receive Columbia River water in lieu of diverting from the Yakima River. The amount or extent of exchange water that could be secured from willing participants in the lower Yakima Valley is critical in addressing the viability of the Black Rock alternative. Consequently, initial study activities involve:

- Identifying irrigation entities that may be willing to exchange water.
- Determining the amount of a water exchange.

These points are necessary to determine the quantity of imported water that could be exchanged and the configuration of the Black Rock alternative facilities necessary to transport such water from the Columbia River to potential exchange participants. This process requires the development of preliminary appraisal-level plans of how to deliver exchange water to their existing systems and the estimated costs of such systems.

The following irrigation entities have been identified as potential water exchange participants: Roza Division (Roza Irrigation District) and Terrace Heights, Selah Moxee, and Union Gap Irrigation Districts; and the Sunnyside Division (Sunnyside Valley Irrigation District and eight other irrigation districts, companies, and cities that comprise this divisions). These entities have expressed their willingness to explore water exchange possibilities. No agreements have been made or negotiated for these entities to make the water exchange.

Potential delivery system alternatives for Roza, Terrace Heights, Selah-Moxee I.D. and Union Gap Irrigation Districts are discussed in this report. In order to understand how the systems may be altered to deliver Columbia River exchanged water, this report will address their existing systems and then discuss possible water delivery plans. The delivery system for the Sunnyside Diversion is discussed in the report *Appraisal Assessment of the Black Rock Alternative Delivery System for Sunnyside Division, Technical Series No. TS-YSS-4, December 2004.*

1.1 EXISTING SYSTEMS OF POTENTIAL WATER EXCHANGE PARTICIPANTS

Figure 1-1 shows the location of the main canals of the potential water exchange participants and the relationship to the Black Rock alternative water supply. A description of the existing main delivery systems of these potential water exchange participants follows.

1.1.1 Roza Irrigation District and Terrace Heights Irrigation District

The Roza Irrigation District (Roza I.D.) service area is comparable with the Roza Division of the Yakima Project. The division was authorized in 1935 by the President for construction by the Bureau of Reclamation (Reclamation); the first lands were served in 1941.

Roza I.D. provides irrigation water service to about 72,000 acres of land. These lands lie along the northeast (left) side of the Yakima River. The service area is about 65 miles long and up to 3 miles in width. The Roza Canal is the main conveyance facility. Its headworks is located at Yakima River

mile (RM) 127.9, about 11 miles upstream from the confluence of the Naches River. The canal is about 95 miles long and the terminus is in the vicinity of Benton City in the Lower Yakima Valley.

Up to 2,200 cfs can be diverted at the canal's headworks for irrigation and hydroelectric generation. The first 11 miles of the Roza Canal includes a concrete siphon under the Yakima River and a concrete tunnel through the Yakima Ridge. At Roza Canal mile post (MP) 11.0, just below the outlet of Yakima Ridge Tunnel No. 3, about 1,020 cfs can be diverted (bifurcated) to the Roza Power Plant for hydroelectric generation. This power flow passes through the Roza Power Plant and re-enters the Yakima River through Wasteway No. 2 at RM 113.3.

Power generated at Roza Power Plant is credited to Roza I.D. to offset power used by its pumping plants. Excess energy is marketed by the Bonneville Power Administration (BPA). Irrigation water is diverted only during the irrigation season. Power water can be diverted year round except during periods of icing and when the operation of the power plant is subordinated for fish by leaving water instream in the Yakima River bypass reach (RM 127.9 to RM 113.3).

Upstream from Tunnel No. 3 inlet (MP 8.8), Roza I.D. delivers about 40 cfs for irrigation service to the area identified as "Roza-Selah Lands." Lands above the canal are served by Pumping Plant No. 1 (MP 7.2). Gravity service is provided to lands below the canal.

Below the bifurcation works, the canal's carrying capacity is reduced to about 1,100 cfs. Lands between this point and the Roza Canal's intersection with State Highway 24 (MP 22.6) require about 175 cfs for irrigation service. In this 11-mile section there are three pumping stations: Terrace Heights Pumping Plant (MP 13.0) which serves the Terrace Heights Irrigation District (Terrace Heights I.D.) pursuant to an agreement with Roza I.D.; and Roza I.D. Pumping Plants No. 2 (MP 16.8) and No. 3 (MP 22.5). Gravity service is provided to down slope Roza I.D. lands.

Below Highway 24 (MP 22.6), Roza I.D. requires approximately 885 cfs for irrigation service. Lands above the Roza Canal are served by an additional 15 pumping plants; lands below the canal receive gravity service. In total, Roza pump lands comprise about 27,000 of the 72,000 acres.

Reclamation and Roza I.D. jointly maintain the first 11 miles of the canal and the diversion dam; operation is Reclamation's responsibility. Roza I.D. is responsible for all operation and maintenance (O&M) of the pumping plants and laterals upstream from Roza Canal MP 11.0, and all facilities downstream.

1.1.2 Selah-Moxee Irrigation District

The Selah-Moxee Irrigation District (Selah-Moxee I.D.) diverts water from the Yakima River into the Selah-Moxee Canal at RM 23.6, near Pomona. The canal runs parallel to and downhill from the Roza Canal, tunnels through the Yakima Ridge, and ends in the southeast side of the Moxee Valley. Selah-Moxee I.D. serves irrigation water to about 5,800 acres. In 1997, the Moxee Ditch Company and the Moxee-Hubbard Irrigation Company, with a total service area of about 2,000 acres, merged into the Selah-Moxee I.D. Those two entities receive water via a pipe drop structure downstream of Selah-Moxee Yakima Ridge Tunnel or from pumps located in the Roza Power Plant Wasteway; these facilities are operated by Selah-Moxee. I.D. Moxee Ditch and the Moxee-Hubbard Canal run parallel and down slope of the Roza and Selah-Moxee Canals, ending in the Moxee Valley.

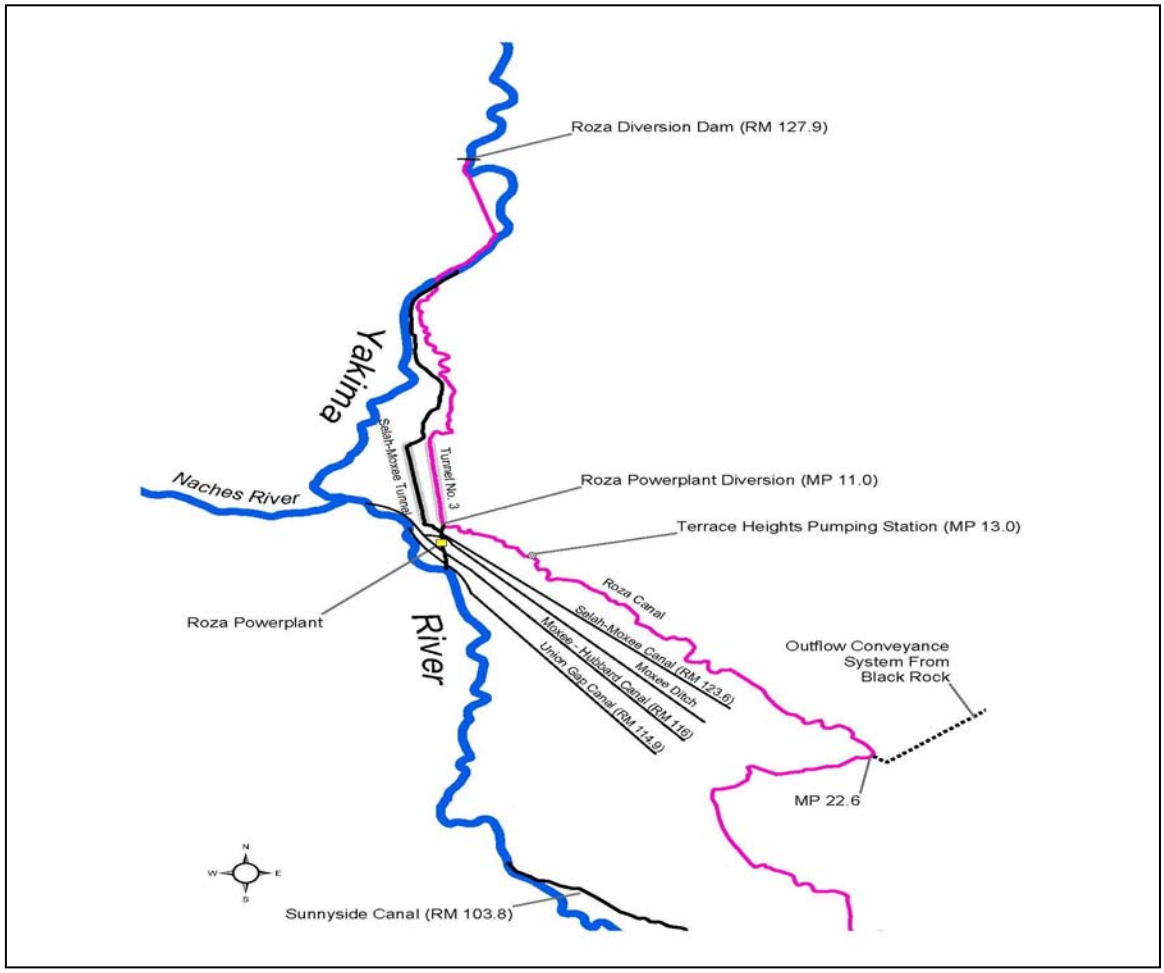
Water delivery requirements of Selah-Moxee I.D. above their Yakima Ridge tunnel is 20 cfs; delivery required below the tunnel, including the merged areas, is 80 cfs.

1.1.3 Union Gap Irrigation District

Union Gap Irrigation District (I.D.) diverts from the Yakima River into the Union Gap Canal at RM 114.9. The canal runs through the Moxee Valley parallel to and downslope from the canals described above. It continues in pipeline and flume through the Union Gap. At a point above the Sunnyside Diversion Dam, it continues in a canal parallel and upslope of the Sunnyside Canal. Approximately 1,700 acres are served in the Moxee Valley, mostly between the canal and the Yakima River. Another 2,950 acres are served in the lower Yakima Valley, mostly between the Union Gap Canal and the Sunnyside Canal, before ending north of Zillah. Irrigation facilities are operated by Union Gap I.D.

The irrigation water delivery requirement is 70 cfs.

Figure 1–1. Schematic drawing of potential water exchange participant's existing irrigation systems, diversion points (in parenthesis), and connection to the Black Rock alternative.



2. WATER DELIVERY SYSTEM PLANS

Columbia River water pumped to a potential Black Rock reservoir would be released into an outflow conveyance system transporting the water west to the Roza Canal (at MP 22.6) and State Highway 24 intersection. The potential Black Rock outlet facility would be on the southeast corner of Roza Canal. The facility would include a Black Rock powerplant, a bypass structure to permit water deliveries when the unit was off-line or to pass flows in excess of powerplant design flows, a flowmeter, and manifold piping and valving for pressure pipe diversions to Roza and Sunnyside Divisions.

The potential Black Rock outlet facility is described in the report, *Appraisal Assessment of the Black Rock Alternative Facilities and Field Cost Estimates, Technical Series No. TS-TSS-2* (December 2004). This document noted that the configuration of the Black Rock powerplant would depend on the type of system selected to deliver water to the potential exchange participants (including Sunnyside Division). At this time, two powerplant configurations were developed: one with a turbine design flow of 1,500 cfs and output of 38 MW and the other with a turbine design of 900 cfs and an output of 23 MW.

The service areas of the four potential water exchange participants addressed in this report are shown on Figure 2-1. These service areas in relation to Roza Canal MP 22.6 are:

- Roza I.D. – both upstream and downstream with the majority of its service being downstream
- Terrace Heights I.D. – upstream from the Roza Canal at MP 13.0
- Selah-Moxee I.D. – upstream
- Union Gap I.D. – downstream

The proposed point-of-delivery of Columbia River exchange water to Selah-Moxee I.D. and Union Gap I.D. is near Roza Canal MP 11.7. This is where the exiting delivery canals of these two irrigation districts are in close proximity to the Roza Canal.

With a Black Rock alternative, Columbia River water available at Roza Canal MP 22.6 could replace a major portion of Roza I.D.'s current Yakima River irrigation diversions to meet downstream demands. This exchange water could continue to be delivered to downstream Roza I.D. lands by the Roza Canal with no need for new delivery facilities. However, delivery of exchange water to upstream Roza I.D. lands and to the Terrace Heights, Selah-Moxee, and Union Gap Irrigation Districts would require new delivery facilities and modifications to existing facilities.

2.1 APPRAISAL-LEVEL PLANS

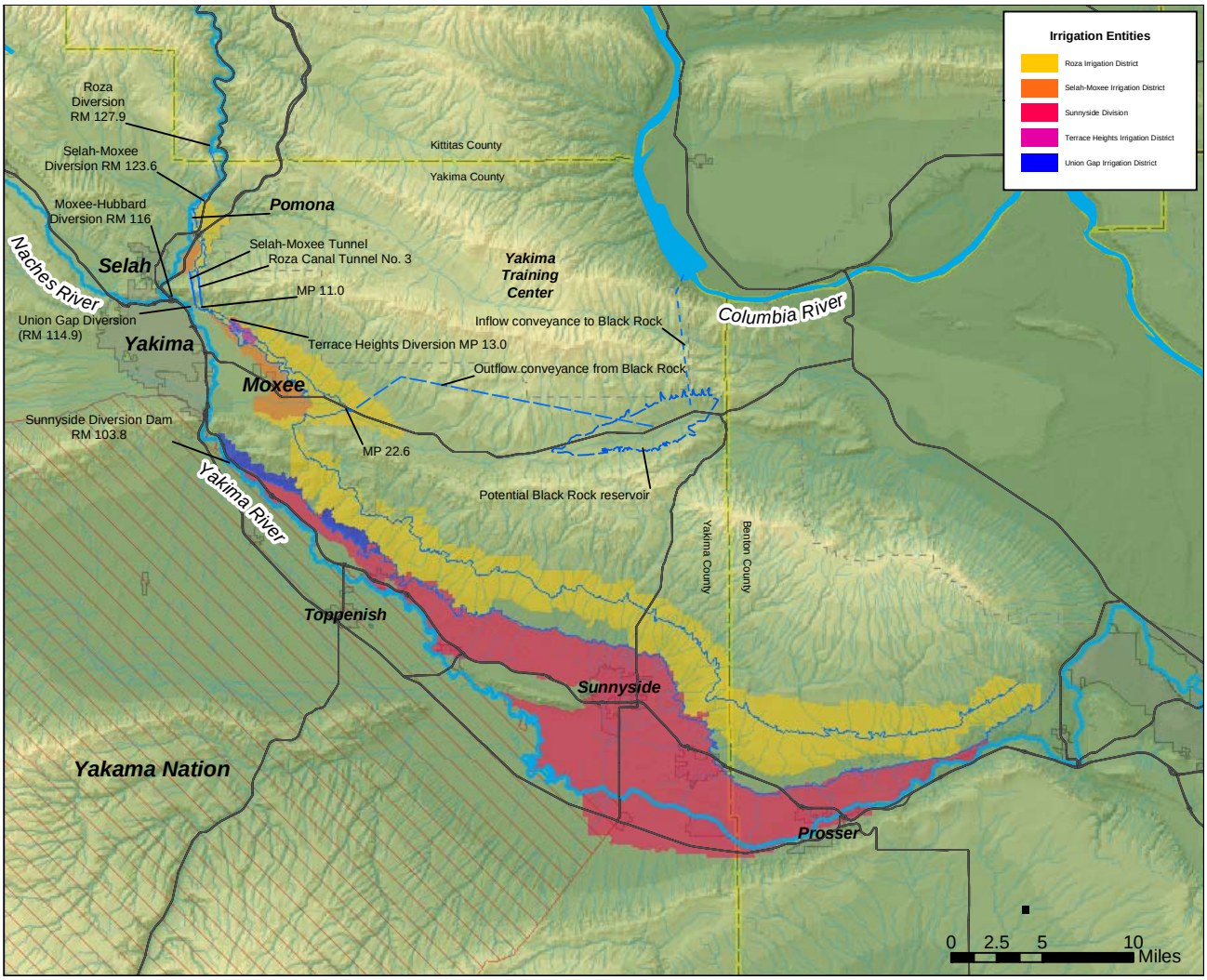
Six appraisal-level plans have been developed for the potential delivery of Columbia River exchange water from Roza Canal MP 22.6 upstream to Roza, Terrace Heights, Selah-Moxee, and Union Gap Irrigation Districts. Plans 1, 2, 3, and 4 would involve construction of a mainline delivery system extending from the Black Rock outlet facility. Plan 5 would involve installation of checks and pumps in Roza Canal to reverse the flow. Plan 6 would require no new construction.

The water delivery plans developed to date could result in a Columbia River irrigation water exchange of up to 1,210 cfs; the current Yakima River supply is 1,270 cfs. Table 2-1 summarizes the irrigation requirements of these four potential exchange participants upstream and downstream from Roza Canal MP 22.6 and identifies possible water supply sources for each plan.

Table 2-1. Preliminary irrigation requirements in CFS based on six appraisal-level water delivery plans

	Plan 1	Plan 2	Plan 3	Plan 4	Plan 5	Plan 6
UPSTREAM FROM ROZA CANAL MP 22.6						
Irrigation Requirements	385	385	385	385	385	385
Potential Columbia River Supply						
Roza I.D. and Terrace Heights I.D.	215	175	175	175	175	35
Selah-Moxee I.D.	—	—	—	80	80	—
Union Gap I.D.	—	—	—	70	70	—
Total Columbia River Supply	*215*	*175*	*175*	*325*	*325*	*35*
Continued Yakima River Supply						
Roza I.D. and Terrace Heights I.D.	—	40	40	40	40	180
Selah-Moxee I.D.	100	100	100	20	20	100
Union Gap I.D.	70	70	70	—	—	70
Total Continued Yakima River Supply	***170***	***210***	***210***	***60***	***60***	***350***
Total Upstream from MP 22.6	**385**	**385**	**385**	**385**	**385**	**385**
DOWNSTREAM FROM ROZA CANAL MP 22.6						
	Plan 1	**Plan 2**	**Plan 3**	**Plan 4**	**Plan 5**	**Plan 6**
Irrigation Requirements	885	885	885	885	885	855
Potential Columbia River Supply						
Roza I.D.	885	885	885	885	885	855
Total Potential Columbia River Supply	*885*	*885*	*885*	*885*	*885*	*855*
Continued Yakima River Supply						
Roza I.D.	—	—	—	—	—	30
Total Continued Yakima River Supply	—	—	—	—	—	*30*
Total Downstream from MP 22.6	885	885	885	885	885	855
POTENTIAL WATER SUPPLY SOURCES						
Columbia River	1,110	1,060	1,060	1,210	1,210	890
Yakima River	170	210	210	60	60	380
Total Potential Water Supply Sources	1,270	1,270	1,270	1,270	1,270	1,270

Figure 2–1. Irrigated lands of potential water exchange participants.



3. SUMMARY OF PLAN CONSIDERATIONS

3.1 PEAK IRRIGATION FLOWS

For the purpose of sizing facilities for delivery of Columbia River water to the potential water exchange participants, the peak irrigation flows shown in Table 3-1 were used.

Table 3-1. Peak irrigation requirements in CFS used to develop conceptual water delivery plans	
	cfs
Upstream from Roza Canal MP 22.6	
Roza I.D. — Upstream of Tunnel No. 3 Inlet (MP 8.8)	40
Roza I.D. and Terrace Heights I.D. — Downstream of Tunnel No. 3 Outlet (MP 11.0) to MP 22.6	175
Subtotal —Upstream of MP 22.6	*215*
Downstream from Roza Canal MP 22.6	
Roza I.D.	*885*
Subtotal Roza I.D. and Terrace Heights I.D.	***1,100***
Selah-Moxee I.D.	*80*
Union Gap I.D.	*70*
Total for all four irrigation districts	**1,250**

The combined requirement for Roza I.D. and Terrace Heights I.D. is 1,100 cfs. Of this, 215 cfs is for Roza I.D. and Terrace Heights I.D. users upstream from Roza Canal MP 22.6 and 885 cfs downstream from MP 22.6. In addition, flows of up to 1,020 cfs are diverted from the Roza Canal at MP 11.0 for hydropower generation at Roza Powerplant. Selah-Moxee I.D. requires 100 cfs; of this 20 cfs is for lands above their Yakima Ridge Tunnel, and would continue to be supplied from the Yakima River. Union Gap I.D. requires 70 cfs.

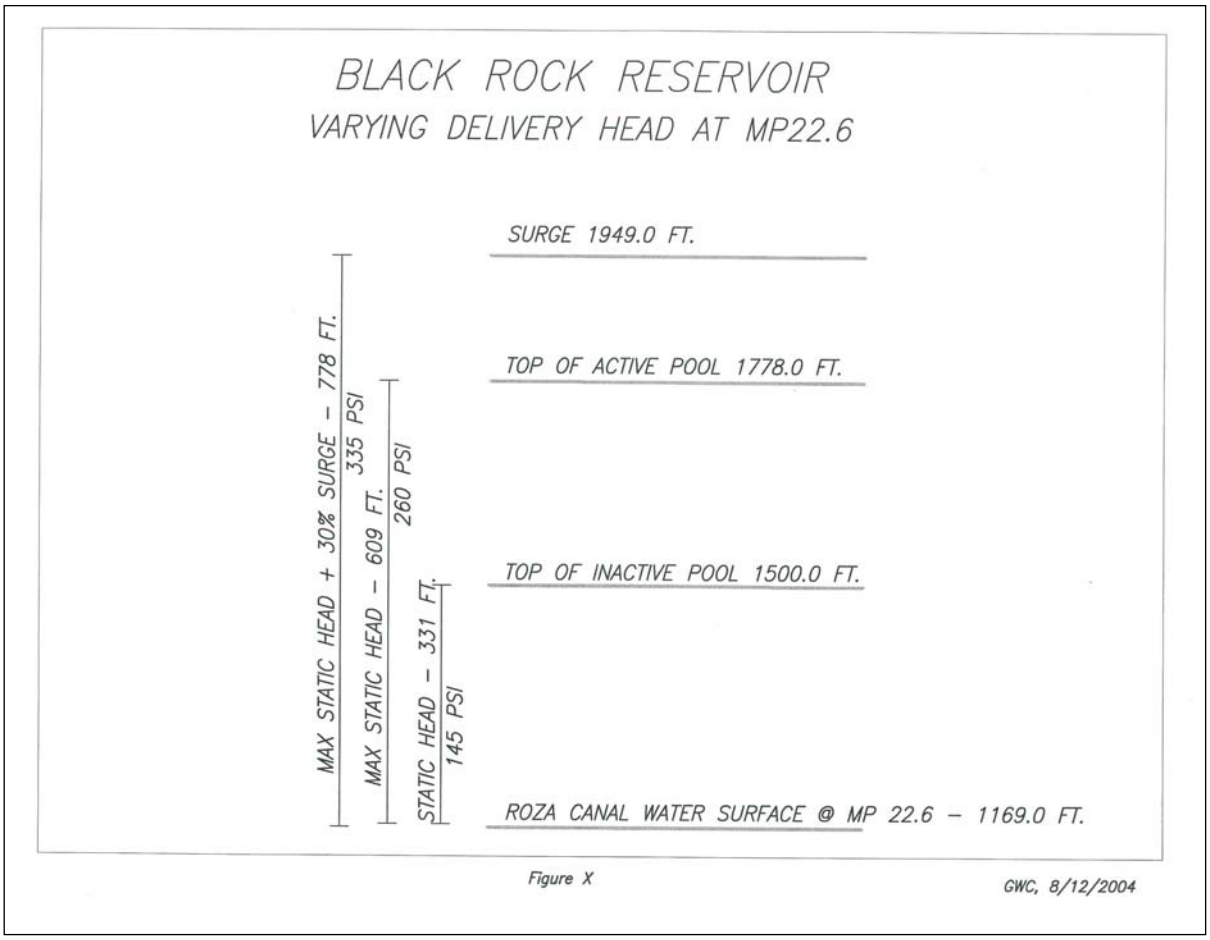
3.2 RESERVOIR ELEVATION – PIPELINE RELATIONSHIPS

For the Black Rock alternative Assessment, the potential Black Rock reservoir total capacity would be 1,457,600 acre-feet; of this, 1,300,000 acre-feet would be active capacity and 157,600 acre-feet would be inactive capacity. The top of the active pool would be elevation 1778 feet (maximum water surface), and the top of the inactive pool would be elevation 1500 feet. The water surface elevation of the Roza Canal at MP 22.6 is 1170 feet. These differences in elevations would result in a static pressure at the Black Rock reservoir outflow conduit bifurcation works ranging from 260 pounds per square inch (psi) to 150 psi depending on the contents of the active pool throughout the irrigation season. (This does not take into account system friction losses.)

The design pressure at the bifurcation works could be as much as 335 psi for a maximum reservoir static pressure plus a 30 percent surge which could occur if water releases from the bifurcation works were abruptly curtailed.

Figure 3-1 illustrates the difference in elevation static pressures.

Figure 3–1. Varying delivery head at Roza Canal MP 22.6 from Black Rock reservoir



3.3 MAINLINE WATER DELIVERY SYSTEM

3.3.1 Pressure Reducing Valve (PRV) System

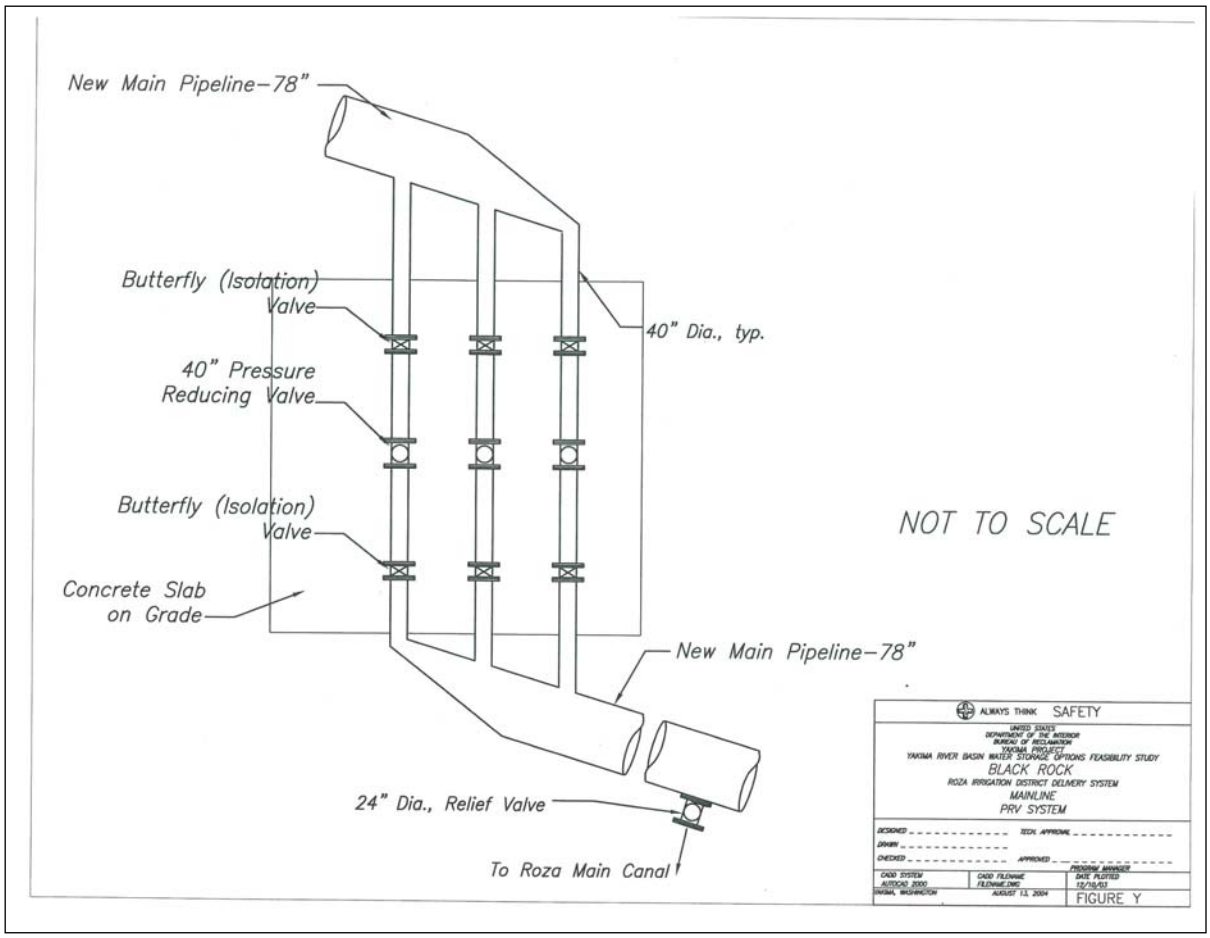
With the potential for significant differences in static pressure, there is the need to ensure the operational integrity and safety of the mainline delivery system which would convey water for irrigation service upstream from Roza Canal MP 22.6. There are several ways to do this:

- by increasing the head class (wall thickness) of the pipe,
- by installing a pressure reducing valve (PRV) system between the bifurcation works and the mainline delivery system,
- by discharging water from the bifurcation works through a generator directly into the Roza Canal and then pumping into the mainline delivery system.

PRV systems were discussed with the Cla-Valve Company of Newport Beach, California. To operate over the range of heads and flows of a Black Rock project, Cla-Valve proposed a system of three Tytan 40-inch valves in parallel, and a 24-inch pressure-relief safety valve downstream of the

pressure reducing valves. This system would use standard manufactured Cla-Valves in its design application. A schematic of the mainline PRV system proposed by Cla-Valve at the bifurcation works is shown in Figure 3-2.

Figure 3–2. Typical mainline PRV (pressure relief valve) system



3.3.2 Pipeline Characteristics

Plans 1 through 4 for mainline delivery systems would contain the following common features.

- A buried steel pipeline would originate at the potential Black Rock outlet facility bifurcation works. The static pressure resulting from the difference in head between stored water elevations (in a Black Rock reservoir) and mainline delivery system elevations would provide for upstream conveyance. A PRV system installed between the bifurcation works and the pipeline would dissipate any excess pressure to ensure the reliability and safety of the mainline delivery system.
- A buried steel pipeline would originate at a new pumping plant in Roza Canal at MP 22.6. Water discharged from the outlet facility through a new Black Rock powerplant would be pumped into the steel pipeline for upstream conveyance. Pressure would dissipate by discharging water through the generator.

3.3.3 Hydraulic Gradelines

The hydraulic gradelines of the mainline delivery systems for Plans 1 through 4 are shown in Attachment B. For example, here is an explanation of these figures using the figure for Plan 1.

- The hydraulic gradeline for the pipeline is shown in blue. This represents the static head in the pipeline.
- The Roza Canal water surface or the delivery elevation is shown in magenta at various stations along the canal, most notably at the existing pumping plants and at points halfway in between the pumping plants.
- Design flows for the system are shown in rectangles at the pumping plant stations to indicate deliveries at each pumping plant and canal turnouts per canal reach (150 cfs, 61 cfs, and so on). Below the design flows are the pipe diameters to show the downsizing of the pipe due to the drop in flow at the pumping plants and turnouts (60-inch diameter to 57-inch diameter, and so on).
- The delivery elevations of the existing pumping plants are shown by green triangles.

The full length of the mainline delivery system is designed for beginning static heads at the upstream end plus 30 percent for transients. For instance in Attachment B, the figure "Options 1 and 1A, Full Exchange, High Pressure Pipe," the static head is 1,494.52 feet; some type of pressure reducing system would be required to prevent overpressure of the Pumping Plant No. 3 discharge line. As long as the hydraulic grade line at the points of delivery are greater than the delivery elevations of the existing pumping plants, and the reservoir elevation is 1650 feet and greater, water delivery to the high elevation lateral can be provided by gravity pressure. However, when the hydraulic grade line at the point of delivery is less than the delivery elevations of the existing pumping plants, such as Pumping Plant No.1, water must be delivered into the pump sump for subsequent pumping to the high elevation lateral.

For Options 1-A through 4-A of Plans 1 through 4, new pumping plants would pump water from the Roza Canal into the mainline delivery system at the required flows and beginning heads. Table 3-2 provides information for these new pumping plants.

Table 3-2. Options 1-A, 2-A, 3-A, and 4-A — Pumping Plant Stations off Roza Canal

Plant Number	Peak demand flow (in cfs)	Plant operating horsepower (hp)	Operating units (each)	TDH at peak flows (in feet)
1-A	215	12,000	6	350
2-A	175	10,000	5	345
3-A	175	2,750	5	100
4-A	325	9,000	6	160

Plant horsepower is based on demand flow plus 5 percent for wear, without spare.
Pump/motor combined efficiency is 75 percent

Plant No. 1-A — 215 CFS		
Unit	**Horsepower**	**Type**
1	2,000	Fixed
2	2,000	Fixed
3	2,000	Fixed
4	2,000	Fixed
5	2,000	VFD
6	2,000	VFD
7 (spare)	2,000	Fixed
TOTAL	**14,000**	

Plant No. 3-A — 175 CFS		
Unit	**Horsepower**	**Type**
1	550	Fixed
2	550	Fixed
3	550	Fixed
4	550	VFD
5	550	VFD
6 (spare)	550	Fixed
TOTAL	**3,300**	

Plant No 2-A — 175 CFS		
Unit	**Horsepower**	**Type**
1	2,000	Fixed
2	2,000	Fixed
3	2,000	Fixed
4	2,000	VFD
5	2,000	VFD
6 (spare)	2,000	Fixed
TOTAL	**12,000**	

Plant No. 4-A — 325 CFS		
Unit	**Horsepower**	**Type**
1	1,500	Fixed
2	1,500	Fixed
3	1,500	Fixed
4	1,500	Fixed
5	1,500	VFD
6	1,500	VFD
7 (spare)	1,500	Fixed
TOTAL	**10,500**	

3.3.4 Farm Service Deliveries to Roza I.D. and Terrace Heights I.D.

Farm service deliveries for Roza I.D. and Terrace Heights I.D. upstream of Roza Canal MP 22.6 would be by means of turnouts from the mainline delivery system to both up-slope and down-slope lands. Up-slope and down-slope irrigation deliveries are discussed below.

3.3.4.1. Up-slope of Mainline Delivery System

Up-slope lands are presently served by pumping stations at Roza Canal mile posts 7.2, 13.0 (Terrace Heights I.D.), 16.8, and 22.5; these lift water from the canal to higher-elevation laterals. These pumping stations consist of a concrete channel (or pump sump) perpendicular to the Roza Canal. Flow from the Roza Canal into the pump sump can be controlled by stop logs. (See Attachment F-5, drawing 33-D-3063, "Mile 7.2 Pumping Plant.")

When delivery of exchange water to the Roza-Selah lands is involved, the water is released to the pump sump of the pumping plant at Roza Canal MP 7.2. Existing pumping plants of Roza I.D. (MP 16.8 and MP 22.5) and Terrace Heights I.D. (MP 13.0) would continue to be used in conjunction with the new mainline delivery systems in the following manner.

With a high-pressure pipeline system originating at the bifurcation works, a dual operation would be required contingent on the Black Rock reservoir water surface elevation. When the reservoir was at elevation 1650 feet and higher, water released from the mainline delivery system would be routed though a new PRV system to the existing pumping plant discharge manifold extending to the high-elevation lateral.

When the reservoir water surface was lower than elevation 1650 feet, water would be routed through the new PRV system to the existing pump sump for subsequent pumping to the high-elevation lateral. With a low-pressure pipeline, released would go into the existing pump sump and then would be pumped to the high-elevation lateral.

For a high-pressure system beginning at a new Roza Canal pumping plant, water released from the mainline delivery system for service to upslope lands always would be routed through the existing pumping plant discharge manifold to the high-elevation lateral. A low-pressure system starting at the same point would make releases to the existing pump sump for pumping at the existing plant to the high-elevation lateral.

Table 3-3 summarizes the above with respect to mainline water deliveries to existing Roza Canal pumping plants (mile posts 13.0, 16.8, and 22.5) servicing lands upslope of the canal. For purposes of discussing the individual plans, the two locations of the mainline inlet (at the bifurcation and at a new pumping plant) are identified in each plan, i.e. for Plan 1, a mainline pipeline inlet at the bifurcation is Option 1 and a mainline pipeline inlet at a new pumping plant is Option 1-A.

Water would be delivered to the high-elevation laterals at the same pressure as currently provided. (See Attachment E, drawing 133-155T-376, "Manifold to Supply Existing Pumping Plants ...")

Table 3-3. Water delivery by mainline delivery system to lands upslope of Roza Canal			
Pipeline Inlet	**Type of system**	**Releases routed to:**	**Is pumping required at existing plants?**
New Bifurcation	High pressure	Existing pump manifold discharge to high-elevation lateral	No – if reservoir water surface were at elevation 1650.0 feet or higher
		Existing pump sump to high-elevation lateral	Yes – if reservoir water surface level were lower than elevation 1650 feet
	Low pressure	Existing pump sump to high elevation lateral	Yes – regardless of reservoir water surface elevation
New Pumping Plant	High pressure	Existing pump manifold discharge to high-elevation lateral	No
	Low Pressure	Existing pump sump to high-elevation lateral	Yes – regardless of reservoir water surface elevation

3.3.4.2 Downslope of Mainline Delivery System

Down-slope lands of the Roza I.D. and Terrace Heights I.D. are presently served by individual gravity turnouts from the Roza Canal. The down-slope mainline delivery system would be fed by valved and metered individual turnouts from the mainline and new pipelines (6 inches to 10 inches in diameter) that would cross over or under the existing Roza Canal. The turnouts would have a meter and pressure reducing valve(s) to ensure a downstream pressure of 40-60 psi. (See Attachment E, drawing 33-155T-377 "Typical Downslope Farm Turnout.")

3.3.5 Farm Service Deliveries to Selah-Moxee I.D. and Union Gap I.D.

The water delivery facilities to Selah-Moxee I.D. and Union Gap I.D. would include a pipe/drop turnout structure from the mainline delivery system at about Roza Canal MP 11.7. Exchange water would be diverted to the irrigation canals of these two irrigation districts via 36-inch and 33-inch diameter pipes, respectively.

4. UPSTREAM PLANS 1–6

Six upstream plans provide various combinations of delivery of Columbia River water to Roza Terrace Heights, Selah-Moxee, and Union Gap Irrigation Districts. Plans 1, 2, 3, and 4 would involve construction of a mainline delivery system extending from the Black Rock outlet facility. Plan 5 would involve installation of checks and pumps in Roza Canal to reverse the flow. Plan 6 would require no new construction.

During the development of delivery system plans, the matter of ensuring that the mainline system would never be subjected to full reservoir head became a concern. As noted, this was discussed with Cla-Valve and information was obtained on the configuration and cost of a PRV system at the bifurcation works.

Options 1, 2, 3 and 4 of Plans 1 through 4 include a PRV system at the connection of the mainline delivery system to the bifurcation works of the potential Black Rock outlet facility. Delivery systems addressing the reservoir head concern by other means were also developed. This was done by discharging through the outlet facility into the Roza Canal and them pumping into a mainline delivery system. These are identified as Options 1-A, 2-A, 3-A, and 4-A (of Plans 1 through 4). Another option (Option 4-B of Plan 4) was prepared using full-head-class pipe beginning at the bifurcation works. This option relies on the wall thickness of the pipe instead of a PRV system to handle the system pressure.

A description of the potential Black Rock reservoir outflow conduit, bifurcation works, and Black Rock powerplant is provided in the report *Appraisal Assessment of the Black Rock Alternative Facilities and Field Cost Estimates, Technical Series No. TS-YSS-2; December 2004.*

The "construction cost" estimates shown for each plan summary are appraisal-level field construction cost estimates. These were developed solely for comparing the plans and options and do not represent the total delivery systems cost if a Black Rock alternative were to be authorized for construction. Chapter 6 describes how these appraisal-level field construction cost estimates were prepared.

4.1 UPSTREAM PLAN 1 – 215 CFS EXCHANGE USING HIGH-PRESSURE PIPELINE

Plan 1 is a total exchange for Roza I.D. and Terrace Heights I.D., whose combined April-October irrigation requirements (215 cfs) between Roza Diversion Dam and Roza Canal MP 22.6 would be met with Columbia River water. This plan assumes that hydroelectric generation at Roza Powerplant would terminate, and up to 1,020 cfs currently diverted from the Yakima River at Roza Diversion Dam for hydroelectric generation would not be diverted.[1] Roza Canal would be dewatered from Roza Diversion Dam to MP 22.6. Plan 1 would not deliver Columbia River water to Selah-Moxee I.D. and Union Gap I.D.

[1] The existing Roza Canal bifurcation works to the Roza Powerplant is at MP 11.0.

Options 1 and 1-A of Plan 1 involves construction of a high-pressure mainline delivery system. The mainline pipeline would run along the northeasterly side of Roza Canal, through Roza Canal Tunnel No. 3, and end at approximate MP 5.5. This provides up to 40 cfs to the Roza-Selah lands (those lands upstream from the inlet of Roza Canal Tunnel No. 3). Up to 175 cfs would be provided to Roza I.D. and Terrace Heights I.D. lands downstream from the tunnel outlet (MP 11.0 to 22.6).

The appraisal-level field construction cost for Plan 1, Option 1 is estimated at $66 million. The cost of Option 1-A of Plan 1 is $74 million.

The appraisal-level field construction cost of a high-pressure pipe system originating at a new Roza Canal pumping plant (Option 1-A of Plan 1) is $8 million more than a high-pressure system extending from the Black Rock outlet facility (Option 1 of Plan 1). However, Option 1-A eliminates the need for the dual operation associated with providing water to lands upslope of Roza Canal described in Section 3.3.4.1.

Table 4-1. Features of Plan 1, 215 cfs Exchange Using High-Pressure Pipeline

Type of Service	
Option 1	High pressure mainline delivery system with PRV system at bifurcation
Option 1-A	High pressure mainline delivery system with new pumping plant in Roza Canal
Participants	Roza I.D. and Terrace Heights I.D.
Extent of exchange	100 percent (215 cfs)
Construction Cost (Field)	
Option 1	$66.0 million
Option 1A	$74.0 million

4.2 UPSTREAM PLAN 2 – 175 CFS EXCHANGE USING HIGH-PRESSURE PIPELINE

Plan 2 would meet all of the Roza I.D. irrigation requirements from the Columbia River, except for 40 cfs (Roza-Selah lands) and all of the Terrace Heights I.D. requirements.

This plan also would involve only Roza I.D. and Terrace Heights I.D.; however, the extent of the water exchange would decrease to 175 cfs by eliminating delivery of Columbia River water to the Roza-Selah lands. These lands would be served by continuing to divert 40 cfs from the Yakima River. This plan assumes Roza Powerplant would continue to operate, requiring the diversion of up to 1,020 cfs from the Yakima River but that Roza Canal be dewatered from MP 11.0 to MP 22.6.

The new mainline high-pressure pipe system would run along the northeasterly side of Roza Canal, ending at about MP 11.7. The appraisal-level field construction cost of Plan 2, Option 2 is $30.1 million. The cost of Plan 2, Option 2-A is $36 million.

The additional field construction cost for inclusion of the 40 cfs irrigation requirement of the Roza-Selah lands as a part of the water exchange program (in Plan 1, Options 1 and 1-A) is $36 to $38 million.

Table 4-2. Features of Plan 2, 175 cfs Exchange Using High-Pressure Pipeline	
Type of Service	
Option 2	High pressure mainline delivery system with PRV system at bifurcation
Option 2A	High pressure mainline delivery system with new pumping plant in Roza Canal
Participants	Roza I.D. and Terrace Heights I.D.
Extent of exchange	96 percent (175 cfs)
Field Construction Costs	
Option 2	$30.1 million
Option 2-A	$36.0 million

4.3 Upstream Plan 3 – 175 cfs Exchange Using Low-Pressure Pipeline

Plan 3 delivers 175 cfs of Columbia River water in the same manner as Plan 2 – 175 cfs for Roza I.D. and Terrace Heights I.D. but not to the Roza-Selah lands. The new mainline delivery system would be low pressure; this would result in a decrease of the wall thickness of the steel pipe. It would require continued use of the existing pumping plants to lift water to the high-elevation laterals up-slope of Roza Canal. This plan assumes Roza Powerplant would continue to operate, but that Roza Canal would be dewatered from MP 11.0 to MP 22.6.

Option 3 (of Plan 3) is similar to Option 2 (of Plan 2), but the delivery system would be operated at lower head (beginning head is elevation 1270 feet instead of 1500 feet). This would deliver water into the existing Roza I.D. pumping plant sumps, without pressure. Pressure heads to other farm turnouts would vary from 97 feet to 4 feet. Excess head from the potential Black Rock reservoir would be reduced with a pressure reducing system.

The construction cost of Option 3 of Plan 3 is $30.1 million; the cost of Option 3-A is $33 million.

The appraisal-level field construction cost of a high-pressure pipeline and a low-pressure pipeline originating at the outlet facility and conveying the same flows to the same delivery points is identical.

Table 4-3. Features of Plan 3, 175 cfs Exchange Using Low-Pressure Pipeline	
Type of Service	
Option 3	Low pressure mainline delivery system with PRV system at bifurcation
Option 3-A	Low pressure mainline delivery system with new pumping plant in Roza Canal
Participants	Roza I.D. and Terrace Heights I.D.
Extent of exchange	96 percent (175 cfs)
Field Construction Costs	
Option 3	$30.1 million
Option 3-A	$33.0 million

4.4 UPSTREAM PLAN 4 – 325-CFS EXCHANGE CONSIDERING THREE PIPELINE OPTIONS

Upstream Plan 4 would provide a total of 325 cfs of exchange water and includes all potential water exchange participants upstream from Roza Canal MP 22.6 (Roza, Terrace Heights, Selah-Moxee, and Union Gap Irrigation Districts). This plan would meet all of the Roza I.D. and Terrace Heights I.D. irrigation requirements of 175 cfs (except for the Roza-Selah lands), and the 70 cfs Union Gap I.D irrigation requirement. Selah-Moxee I.D. would get 80 cfs of its 100 cfs requirement. Yakima River diversions of 60 cfs (40 cfs for the Roza-Selah lands and 20 cfs for Selah-Moxee lands) would continue. Exchange water for Selah-Moxee I.D. and Union Gap I.D. would be delivered into their existing canals from the mainline pipeline by turnout/drop structures near MP 11.7. Plan 4 assumes Roza Powerplant would continue to operate (requiring the diversion of up to 1,020 cfs from the Yakima River) and that Roza Canal would be dewatered from MP 11.0 to MP 22.6.

Plan 4 considers three mainline delivery systems.

- Option 4 is a low-pressure pipeline extending from the outlet facility bifurcation works.
- Option 4-A is a low-pressure pipeline extending from a new Roza Canal pumping plant.
- Option 4-B is a high-pressure, full-head-class pipe system beginning at the outlet facility bifurcation works. This option would rely on the wall thickness of the pipe instead of a PRV system to handle the system pressure, thereby removing concerns that a PRV system may not consistently operate to ensure system pressure attributed to the head differential would not bypass the PRV system

An additional 150 cfs (for Selah-Moxee I.D. and Union Gap I.D.) could be obtained for a water exchange at a field construction cost of $29.0 to $31.0 million (Plan 4 compared to Plan 3). The bifurcation works would have significant pressure variations. If there are concerns about the reliability of a PRV system and a full-head-class pipe is required, the field construction cost increases by about $54.0 million (Option 4-B compared to Option 4).

Table 4-4. Features of Plan 4, 325 cfs Exchange Considering Three Pipeline Options

Type of Service	
Option 4	Low pressure mainline delivery system with PRV system at bifurcation
Option 4A	Low pressure mainline delivery system with new pumping plant in Roza Canal
Option 4B	High pressure mainline delivery system with full head class pipe
Participants	Roza I.D., Terrace Heights I.D., Selah-Moxee I.D., and Union Gap I.D.
Extent of exchange	Roza I.D. and Terrace Heights I.D. – 96 percent (175 cfs) Selah-Moxee I.D. – 80 percent (80 cfs) Union Gap I.D. – 100 percent (70 cfs)
Field Construction Costs	
Option 4	$59.0 million
Option 4-A	$64.0 million
Option 4-B	$113.0 million

4.5 UPSTREAM PLAN 5 – 325 CFS EXCHANGE WITH ROZA CANAL CHECKS AND RELIFT PUMPS

Plan 5 is similar to Plan 4 and it also would deliver 325 cfs to the four upstream irrigation districts. However, this would be accomplished by installing checks and relift pumps to reverse the flow in Roza Canal. This plan would supply 1,210 cfs of Columbia River water from the potential Black Rock outlet facility into Roza Canal at MP 22.6. The flow direction in Roza Canal would be reversed from MP 22.6 to MP 11.0. This would deliver 175 cfs to existing Roza pumping plants and turnouts and an additional flow of 150 cfs to serve Selah-Moxee I.D. and Union Gap I.D.

At Roza Canal MP 11.7, a new turnout/drop structures would deliver 80 cfs into Selah-Moxee Canal south of the Yakima Ridge Tunnel, and 70 cfs into Union Gap Canal. In Roza Canal, the reverse-flow water would be re-lifted in increments of about 5 feet by each of four new relift pumping plants and checks, see Table 4.5.

New pumping plants and checks would be located at Roza Canal MP 20.6 and 18.7. A new pumping plant would be located at the existing check downstream of Pumping Plant No. 2 (MP 16.8), and a new pumping plant and check would be located near Terrace Heights Pumping Plant (MP 13). A terminal check would also be added at Roza Canal MP 11.7.

Delivering Selah-Moxee I.D. and Union Gap I.D. water via Roza Canal would provide adequate flow velocities to keep the reverse-flow water from becoming stagnant. Roza I.D. and Selah-Moxee I.D. lands upstream from the tunnels and Roza Power Plant hydropower generation flows would continue to be provided by diversions from the Yakima River.

Drawing 33-155T-378 in Attachment E shows a typical check-relift structure. The number of relift pump units would vary according to flow requirements for each existing pumping station. These are shown in Table 4-5 Relift pumps would be controlled by sensors in each "checked reach."

This plan assumes Roza Powerplant would continue to operate. Roza Canal from MP 11.7 to MP 22.would be watered-up by the delivery of Columbia River water as the result of the reverse-flow operation. The field construction cost of estimate of Plan 5 is $6.3 million.

Plan 5 results in a 325 cfs water exchange, the same as Plan 4. The field construction cost of Plan 5 is $50 million less than Option 4 of Plan 4.

Table 4-5. Features of Plan 5, 325 cfs Exchange With Roza Canal Checks And Relift Pumps

Type of Service	
Option 5	Checks and relift pumps in Roza Canal to reverse the flow.
Participants	Roza I.D. and Terrace Heights I.D., Selah-Moxee Irrigation District, and Union Gap Irrigation District
Extent of exchange	Roza I.D. and Terrace Heights I.D.: 96 percent (175 cfs)
	Selah-Moxee Irrigation District: 80 % (80 cfs)
	Union Gap Irrigation District: 100% (70 cfs)
Field Construction Cost	
Option 5	$6.3 million

Table 4-6. Plan 5 – Relift Pumping Plant Stations					
Plant No.	**Peak demand flow** (cfs)	**Flow plus 10% recovery, plus 5% wear** (cfs)	**Plant operating horsepower** (in hp)	**Operating units** (each)	**TDH at peak flows** (in feet)
1	256	296	550	5	12
2	240	277	510	5	12
3	236	273	500	5	12
4	156	180	330	4	12

Plant horsepower is based on demand flow plus 10% recovery plus 5% for wear, without spare.
Pump/motor combined efficiency is 75 percent.

Plant No. 1 — 256 cfs		
Unit No.	**Horsepower** (hp)	**Type**
1	110	VFD
2	110	VFD
3	110	VFD
4	110	VFD
5	110	VFD
6 (spare)	110	VFD
Total	**600**	

Plant No. 3 — 236 cfs		
Unit No.	**Horsepower** (hp)	**Type**
1	100	VFD
2	100	VFD
3	100	VFD
4	100	VFD
5	100	VFD
6 (spare)	100	VFD
Total	600	

Plant No. 2 — 240 cfs		
Unit No.	**Horsepower** (hp)	**Type**
1	100	VFD
2	100	VFD
3	100	VFD
4	100	VFD
5	100	VFD
6 (spare)	100	VFD
Total	**600**	

Plant No. 4 — 156 cfs		
Unit No.	**Horsepower** (hp)	**Type**
1	85	VFD
2	85	VFD
3	85	VFD
4	85	VFD
5 (spare)	85	
Total	425	

4.6 UPSTREAM PLAN 6 – 35 CFS EXCHANGE

Under Plan 6, the only upstream water exchange would be with Roza I.D. It would involve the delivery of 35 cfs of Columbia River water to meet a portion of the irrigation requirement at Pumping Plant No. 3 (65 cfs) at Roza Canal MP 22.5. Table 4-7 shows that Yakima River diversions would continue at 180 cfs.

Table 4-7. Plan 6, Upstream Delivery, Yakima River Diversion Requirement

Upstream from MP 11.0 (Roza-Selah lands)	—	40 cfs
MP 11-0 to MP 22.6 (total requirement)	175 cfs	—
<less> Pumping Plant No. 3 exchange	<35 cfs>	—
Residual	—	140 cfs
Yakima River irrigation diversions		180 cfs

The 35 cfs would be provided at Pumping Plant No. 3 from the backflow of Columbia River water discharged from the Black Rock outlet facility through a Black Rock powerplant into Roza Canal at MP 22.6. The Yakima River would provide the remaining 30 cfs required at Pumping Plant No. 3. In addition to the 180 cfs Yakima River Diversion to meet other upstream irrigation requirements, 30 cfs would also be diverted as flow-through water to keep the canal from getting stagnant. This flow-through water would then be used for irrigation downstream from Roza Canal MP 22.6. Table 4-8 summarizes the features of Plan 6.

Table 4-8. Features of Plan 6, 35 cfs Exchange

Type of Service	
Option 6	Pumping Plant No.3 by backflow from Roza Canal
Participants	Roza I.D.
Extent of exchange	Roza I.D. and Terrace Heights I.D. – 16 percent (35 cfs)
Field Construction Cost	
Option 6	None

Table 4-9 provides a summary of all upstream potential water delivery plans.

Table 4-9. Summary of Upstream Potential Water Delivery System Plans						
Item	**Option**					
	1 and 1-A	2 and 2-A	3 and 3-A	4, 4-A, 4-B	5	6
Water Source						
Roza I.D.	CR	CR d/s MP 11 YR u/s MP 11	CR d/s MP 11 YR u/s MP 11	CR d/s MP 11 YR u/s MP 11	CR d/s MP 11 YR u/s MP 11	CR d/s MP 11 YR u/s MP 11
Selah-Moxee I.D.	YR	YR	YR	CR d/s tunnel YR u/s tunnel		YR
Union Gap I.D.	YR	YR	YR	CR	CR	YR
Columbia River Water Delivery upstream of MP 22.7 (cfs)						
Roza I.D.	215	CR 175 YR 40	CR 175 YR 40	CR 175 YR 40	CR 175 YR 40	CR 35 YR 180
Selah-Moxee I.D.	n/a	n/a	n/a	CR 80 YR 20	CR 80 YR 20	n/a
Union Gap I.D.	n/a	n/a	n/a	70	70	n/a
Type of Service						
Roza I.D. – u/s of MP 11	HPP	gravity canal	gravity canal	gravity canal	gravity canal	gravity canal
Roza I.D. – MP 11 to 22.7	HPP	HPP	LPP	4, 4-A = LPP 4-B = HPP	reverse canal	gravity canal
Selah-Moxee I.D.	n/a	n/a	n/a	pipe turnout; drop	Reverse canal; pipe turnout; drop	n/a
Union Gap I.D.	n/a	n/a	n/a	pipe turnout; drop	Reverse canal; pipe turnout; drop	n/a
Roza Powerplant operation	No	Yes	Yes	Yes	Yes	Yes
Roza Canal dewatered	YR to MP 22.6	YR to MP 22.6	YR to MP 22.6	YR to MP 22.6	None	None
Field Construction Cost Estimates (in millions)						
Option with PRV system	$66.0	$30.1	$30.1	$59.0		
Option with pumping plant	$74.0	$36.0	$33.0	$64.0		
Full-head-class pipe				$113.0		
Reverse flow					$6.3	
CR = Columbia River; YR = Yakima River; u/s = upstream; d/s = downstream; HPP = high-pressure pipe; LPP = low-pressure pipe; Roza Powerplant is at MP 11						

5. DOWNSTREAM PLANS

Roza I.D. irrigation requirements downstream from Roza Canal MP 22.6 are 885 cfs. This could be met entirely by Columbia River water provided from the potential Black Rock outlet facility into Roza Canal without incurring additional costs for construction of water delivery facilities. This exchange water could then be conveyed to existing pumping plants and turnouts for the irrigation of upslope and downslope lands.

Two plans were developed for a potential water exchange with Sunnyside Division. Delivery of exchange water to Sunnyside Canal at this time could involve either a new pressure-pipe delivery system extending from the potential outlet facility bifurcation through Konnowock Pass to Sunnyside Canal at MP 3.83 or by modifications to Roza Canal combined with a shorter pipeline to Sunnyside Canal at the same discharge point.

For the potential Sunnyside Division water delivery system plan involving modifications to Roza Canal, these would begin at Roza Canal MP 22.6 and consist of a new siphon, enlargement of Roza Canal, and construction of a new Tunnel No. 5 to carry an additional 1,262 cfs flow to about Roza Canal MP 29.2. At this point, the exchange water would be routed into Roza Canal Wasteway No. 3, which would be enlarged from 1,252 cfs to 2,514 cfs to carry the additional flow. Five new check/drop structures would also be installed.

At about 1.75 miles from the wasteway headworks, a new turnout would divert Sunnyside Division exchange water into a new 12-foot-diameter pipeline extending a little over 0.75 miles to Sunnyside Canal MP 3.83.

Further information on these two Sunnyside Division water exchange plans can be found in the report *Appraisal Assessment of the Black Rock Alternative Delivery System for Sunnyside Division, Technical Series No. TS-YSS-4, December 2004.*

6. PRIMARY DELIVERY SYSTEM FEATURES

For Plans 1 through 4, the mainline delivery system features include a steel main pipeline and turnouts from the main pipeline. The pipeline would be located along the uphill side of the Roza Canal and buried with about five feet of cover. Additional right-of-way along agricultural lands would be acquired to provide room for construction. There are several logical alternate pipeline routes shown on Attachment C ("Aerial Photographs") which could shorten and simplify the pipeline construction, but would also require new right-of-way.

The pipeline would be mortar-lined, polytape-wrapped, and welded steel with a cathodic monitoring/protection system. As described in Section 3.3.3, the full-length of the pipeline would be designed for beginning static heads (shown on Attachment B), at the upstream end of the pipeline plus 30 percent for transients. The gradelines shown in Attachment B are for maximum flow using "Hazen Williams C=120" which should provide slightly oversized pipe.

In-line air chambers along the pipeline are not included at this stage of the work and a transient analysis would need to be completed as decisions are made regarding which potential water exchange entities would actually participate in an exchange and the extent of their participation. For Plan 1, involving a Columbia River water exchange with the Roza-Selah lands upstream from the inlet of Roza Canal Tunnel No. 3, the pipeline would be installed in the tunnel arch, supported by steel cross members. The pipeline through the tunnel would have access manholes and air vents at approximate spacing of 2,000 feet.

For Plan 4, Selah-Moxee I.D. and Union Gap I.D. would be served from the main pipeline by larger turnout/ pipeline drop/outlet structures from the main pipeline.

The existing pumping plant sumps would be bulkheaded at canal intakes to hold water at those times when exchange water must be delivered into the pumping plant sumps.

For Plan 5, flow in each of the five canal reaches would be substantially less than the Roza Canal original design flow; therefore, the chemical treatment program for aquatic weed growth would be increased.

7. FIELD CONSTRUCTION COST ESTIMATES

Reclamation's Pacific Northwest Construction Office (PNCO) prepared the appraisal-level field construction cost estimates for Plans 1 through 5. Concepts and assumptions used in this study have not been subject to detailed design and value engineering. Therefore, the reader should not infer the presented concept designs, capacities, assemblies, and quantities imply the best design. Feasibility studies would validate or improve concepts and estimates. Field construction cost estimates would change accordingly as the project develops.

Field construction costs include the itemized pay items of construction contracts, plus costs for contractor mobilization, plus and allowance for "unlisted items" (collectively referred to as "construction contract costs") and contingencies.

Estimated contract pay items are based on competitive prices taken from bid abstracts for similar construction, RS Means and industry cost rate publications, and supplier pricing for commercially available equipment and materials. There were two primary sources of cost data. The first was taken from various bid abstracts for comparable pipeline and pumping plant projects constructed from 1992 to 1998 as part of the Umatilla Basin Project (Oregon). The second was from information in a series of engineering reports in 2002 and 2003 relating to the proposed Kennewick and Columbia Irrigation Districts pump exchange program. Consideration is given for degree of risk and difficulty, worksite conditions, and seasonal construction periods.

The pay item estimates assume work and materials would be obtained by fixed-price, competitive, sealed-bid contracts. Excavation, bedding, and compact backfill are based on excavated quantities being reused. There would be room to stockpile and waste along existing right-of-way, so no excessive haul distance or stockpiling effort would be required.

Pumping plant contract cost estimates for Options 1-A through 4-A of Plans 1 through 4 were taken from a cost curve for finished plants without air chambers or variable frequency drives (VFD). The cost curve was developed by PNCO based on completed construction costs for 70 previous Reclamation pumping plants of various horsepower; it is not included here. Costs were indexed to February 2004 price levels using *Engineering New Record*'s "Construction Cost Index." Pumping-plant line-item costs were based on curve values which were adjusted to mark-ups for removal, unlisted, contingencies, mobilization and tax, and to add air chambers and VFD's.

Mobilization costs include mobilizing contractor personnel and equipment to the work site during initial construction start-up. The pay items subtotal cost is assessed 5% based on past experience with similar projects.

Unlisted items includes numerous small items which do not have enough individual impact to warrant individual pricing, but which in total are significant. Unlisted items are added as a percentage (15%) of the sum of the pay item cost plus the mobilization cost.

Contingencies are then added as a percentage (25%) of the construction contract cost (the sum of the pay items, mobilization costs, and unlisted items) to determine the "field construction cost." Contingencies cover risks and uncertainties during construction to account for construction contract changes and claims to ensure an adequate funding for the construction contract.

It should be noted that additional non-contract costs would need to be incurred once a proposed Federal water resource project was authorized and the Congress provided construction appropriations. These additional costs would include such items a preparation of final engineering designs and specification, regulatory compliance and permitting activities, environmental mitigation and monitoring, and construction contract administration and management. Right-of-way acquisition costs for project construction and subsequent project operation must also be included.

8. PRELIMINARY REACTION TO WATER DELIVERY SYSTEM PLANS

Reclamation submitted a draft water delivery system report to the Roza, Terrace Heights, Selah-Moxee, and Union Gap Irrigation Districts. The preliminary reaction provided is summarized below.

8.1 ROZA IRRIGATION DISTRICT

Roza Irrigation District manager and staff offered the following ideas, concerns, and preferences in meetings to discuss the exchange options.

- Roza I.D. would prefer to run its power plant at MP 11; the district would not support a plan that eliminated its project power.
- Roza I.D. prefers that its canal be watered-up throughout the season because the reinforced lining was not designed with expansion joints. If dewatered, warm temperatures/sunlight on the concrete lining would cause thermal expansion and buckling. Expansion joints have already been added to some sections of concrete lining damaged by thermal expansion and buckling during hot-weather shut downs. Options that dewater reaches of Roza Canal may need to include installation of expansion joints into existing lining at appropriate intervals.
- Roza would be willing to carry Selah-Moxee water above Tunnel No. 3. Roza is reluctant to receive water upstream of Tunnel No. 3 from Selah-Moxee Canal in lieu of Plan 1 piping Black Rock water through Tunnel No. 3. The Selah-Moxee I.D. Diversion has some operational challenges, deliveries would have to be pumped, and the Roza I.D. canal needs to be watered up to prevent thermal buckling.
- Roza is receptive to options that would carry water to Selah-Moxee below Yakima Ridge and Union Gap via Roza Canal or common distribution pipeline.
- Using Columbia River water means no waste allowed, operational waste is a reality, and is difficult to avoid in the event of power failure, unless extensive re-regulation reservoirs are used to capture waste water.
- Canal water-up at beginning of irrigation season requires large flows of water to flush the canal system, and flushing flows are wasted into the Yakima River.
- Roza I.D. wishes to keep existing systems in-place and operational as back-up to Black Rock.
- Roza I.D. prefers gravity supply from Black Rock for reliability.
- Clear water from Black Rock will increase the need for aquatic weed treatment.

8.2 SELAH-MOXEE IRRIGATION DISTRICT

The appraisal-level design for Upstream Plans 4 and 5 would include the delivery of Columbia River water to Selah-Moxee I.D. The district's main canal diverts from the Yakima River near Pomona,

runs parallel to and downslope of Roza Canal, tunnels through the Yakima Ridge, and ends in the southeast side of Moxee Valley.

For design purposes, it was assumed the district's water demand was about 100 cfs with 80 cfs required downstream from the Yakima Ridge tunnel. The Yakima River would deliver the remaining 20 cfs. The appraisal-level design would limit service with use of Columbia River exchange water to the area downstream from the tunnel.

8.3 Union Gap Irrigation District

Appraisal-level design for Upstream Plans 4 and 5 also would include the delivery of Columbia River water to Union Gap I.D. Currently, the district diverts from the Yakima River downstream from Pomona; its main canal is parallel to and downslope of Roza and Selah-Moxee Canals. After passing through Union Gap and to its end point north of Zillah, the canal is upslope of Sunnyside Canal.

All of the Union Gap service area lies downstream from Roza Canal MP 11.0. The district has indicated an interest in receiving Columbia River water as a full in-lieu supply as long as there would be no additional cost to the district.